

WHAT IS CLAIMED IS:

*SA* 1. A soft magnetic film comprising a FeNi alloy containing at least one element  $\alpha$  selected from Tc, Ru, Rh, Pd, Re, Os, Ir and Pt, wherein the composition ratio of the element  $\alpha$  is 1% by mass to 10% by mass.

2. A soft magnetic film according to Claim 1, wherein the composition ratio of the element  $\alpha$  is 1.58% by mass to 4.90% by mass.

3. A soft magnetic film according to Claim 1, wherein the Fe composition ratio is 55% by mass to 90% by mass.

4. A soft magnetic film according to Claim 3, wherein the Fe composition ratio is 72% by mass or more.

5. A soft magnetic film according to Claim 4, wherein the Fe composition ratio is 68% by mass or more.

6. A soft magnetic film represented by the composition formula  $\text{Fe}_d\text{Ni}_e\alpha_f$  (wherein element  $\alpha$  is at least one of Tc, Ru, Rh, Pd, Re, Os, Ir and Pt), wherein the composition ratio d of Fe is 58% by mass to 77% by mass, the composition ratio e of Ni 18% by mass to 37% by mass, the composition ratio f of the element  $\alpha$  is 1% by mass to 12% by mass, and  $d + e + f = 100\%$  by mass.

7. A soft magnetic film represented by the formula  $\text{Fe}_x\text{Ni}_y\alpha_z$  (wherein element  $\alpha$  is at least one of Tc, Ru, Rh, Pd, Re, Os, Ir and Pt), wherein the composition ratio X of Fe is 65% by mass to 74% by mass, the composition ratio Y of Ni 25% by mass to 34% by mass, the composition ratio Z of the element  $\alpha$  is 1% by mass to 7% by mass, and  $X + Y + Z = 100\%$  by mass.

8. A thin film magnetic head comprising a lower core layer made of a magnetic material, a gap layer formed on the lower core layer and made of an insulating material, a coil layer formed on the gap layer and made of a good conductive material, an insulating layer covering the coil layer, and an upper core layer formed on the insulating layer;

wherein at least one of the upper core layer and the lower core layer comprises a soft magnetic film according to Claim 1.

9. A thin film magnetic head according to Claim 8, further comprising a lower pole layer formed on the lower core layer to protrude from a surface facing a recording medium, wherein the lower pole layer comprises a soft magnetic film according to Claim 1.

10. A thin film magnetic film comprising a lower core layer, an upper core layer, and a pole portion located

between the lower core layer and the upper core layer and having a width dimension in the track width direction, which is restricted to be narrower than the lower core layer and the upper core layer;

wherein the pole portion comprises a lower pole layer continued from the lower core layer, an upper pole layer continued from the upper core layer, and a gap layer located between the lower pole layer and the upper pole layer, or the pole portion comprises an upper pole layer continued from the upper core layer and a gap layer located between the upper pole layer and the lower core layer; and

the upper pole layer and/or the lower pole layer comprises a soft magnetic film according to Claim 1.

11. A thin film magnetic head according to Claim 8, wherein at least the portion of the core layer, which is adjacent to the magnetic gap, comprises at least two magnetic layers, or the pole layer comprises at least two magnetic layers, and the magnetic layer of the at least two magnetic layers, which contacts the magnetic gap, comprises a soft magnetic film according to Claim 1.

12. A thin film magnetic head comprising a lower core layer made of a magnetic material, a gap layer formed on the lower core layer and made of an insulating material, a coil layer formed on the gap layer and made of a good conductive material, an insulating layer covering the coil layer, and

an upper core layer formed on the insulating layer;

wherein at least one of the upper core layer and the lower core layer comprises a soft magnetic film according to Claim 6.

13. A thin film magnetic head according to Claim 12, further comprising a lower pole layer formed on the lower core layer to protrude from a surface facing a recording medium, wherein the lower pole layer comprises a soft magnetic film according to Claim 6.

14. A thin film magnetic film comprising a lower core layer, an upper core layer, and a pole portion located between the lower core layer and the upper core layer and having a width dimension in the track width direction, which is restricted to be shorter than the lower core layer and the upper core layer;

wherein the pole portion comprises a lower pole layer continued from the lower core layer, an upper pole layer continued from the upper core layer, and a gap layer located between the lower pole layer and the upper pole layer, or the pole portion comprises an upper pole layer continued from the upper core layer and a gap layer located between the upper pole layer and the lower core layer; and

the upper pole layer and/or the lower pole layer comprises a soft magnetic film according to Claim 6.

15. A thin film magnetic head according to Claim 12, wherein at least the portion of the core layer, which is adjacent to the magnetic gap, comprises at least two magnetic layers, or the pole layer comprises at least two magnetic layers, and the magnetic layer of the at least two magnetic layers, which contacts the magnetic gap, comprises a soft magnetic film according to Claim 6.

16. A thin film magnetic head comprising a lower core layer made of a magnetic material, a gap layer formed on the lower core layer and made of an insulating material, a coil layer formed on the gap layer and made of a good conductive material, an insulating layer covering the coil layer, and an upper core layer formed on the insulating layer;

wherein at least one of the upper core layer and the lower core layer comprises a soft magnetic film according to Claim 7.

17. A thin film magnetic head according to Claim 16, further comprising a lower pole layer formed on the lower core layer to protrude from a surface facing a recording medium, wherein the lower pole layer comprises a soft magnetic film according to Claim 7.

18. A thin film magnetic film comprising a lower core layer, an upper core layer, and a pole portion located between the lower core layer and the upper core layer and

having a width dimension in the track width direction, which is restricted to be shorter than the lower core layer and the upper core layer;

wherein the pole portion comprises a lower pole layer continued from the lower core layer, an upper pole layer continued from the upper core layer, and a gap layer located between the lower pole layer and the upper pole layer, or the pole portion comprises an upper pole layer continued from the upper core layer and a gap layer located between the upper pole layer and the lower core layer; and

the upper pole layer and/or the lower pole layer comprises a soft magnetic film according to Claim 7.

19. A thin film magnetic head according to Claim 16, wherein at least the portion of the core layer, which is adjacent to the magnetic gap, comprises at least two magnetic layers, or the pole layer comprises at least two magnetic layers, and the magnetic layer of the at least two magnetic layers, which contacts the magnetic gap, comprises a soft magnetic film according to Claim 7.

20. A method of producing a soft magnetic film comprising depositing a FeNi alloy containing Pd by an electroplating process, wherein the electroplating process uses a plating bath containing Fe and Ni ions, and further containing  $\text{PdCl}_2$  which is added thereto in an amount of 0.01 g/l to 0.10 g/l based on the total amount of the plating

bath.

21. A method of producing a soft magnetic film comprising depositing a FeNi alloy containing Rh by an electroplating process, wherein the electroplating process uses a plating bath containing Fe and Ni ions, and further containing Rh which is added thereto by adding a strongly acidic Rh addition solution with a Rh content of 100 g/l in an amount of 0.1 g/l to 0.2 g/l based on the total amount of the plating bath.

22. A method of producing a soft magnetic film according to Claim 20, wherein the FeNi alloy containing Pd is deposited by the electroplating process using a pulse current.

23. A method of producing a soft magnetic film according to Claim 21, wherein the FeNi alloy containing Rh is deposited by the electroplating process using a pulse current.

24. A method of producing a soft magnetic film comprising depositing a FeNi alloy by an electroplating process using a pulse current and a plating bath having a Fe ion concentration of 1.0 g/l to 10 g/l, a Ni ion concentration of 5 g/l to 40 g/l, and a concentration of element  $\alpha$  (wherein element  $\alpha$  is at least one of Tc, Ru, Rh,

Pd, Re, Os, Ir and Pt) ion of 0.01 g/l to 0.2 g/l.

25. A method of producing a soft magnetic film according to Claim 24, wherein the Ni ion concentration is 15 g/l or less.

26. A method of producing a soft magnetic film according to Claim 25, wherein the Ni ion concentration is 10 g/l or less.

27. A method of producing a soft magnetic film according to Claim 24, wherein the ion concentration of the element  $\alpha$  is 0.01 g/l to 0.5 g/l.

28. A method of producing a soft magnetic film according to Claim 24, wherein saccharin sodium is mixed with the plating bath.

29. A method of producing a soft magnetic film according to Claim 24, wherein 2-butyne-1,4-diol is mixed with the plating bath.

30. A method of producing a soft magnetic film according to Claim 24, wherein sodium 2-ethylhexyl sulfate is mixed with the plating bath.

31. A method of manufacturing a thin film magnetic



head comprising depositing a lower core layer made of a magnetic material, an upper core layer opposed to the lower core layer with a magnetic gap provide therebetween at a surface facing a recording medium, and a coil layer for inducing a recording magnetic field in both core layers;

wherein at least one of the core layers comprises a soft magnetic film deposited by a production method according to Claim 24.

32. A method of manufacturing a thin film magnetic head according to Claim 32, further comprising forming a lower pole layer on the lower core layer to protrude from a surface facing a recording medium, wherein the lower pole layer comprises a soft magnetic film deposited by a production method according to Claim 24.

33. A method of manufacturing a thin film magnetic head comprising depositing a lower core layer, an upper core layer and a pole portion between the lower core layer and the upper core layer so that the width dimension in the track width direction is limited to a narrower range than the lower core layer and the upper core layer;

wherein the pole portion comprises a lower pole layer continued from the lower core layer, an upper pole layer continued from the upper core layer, and a gap layer located between the lower pole layer and the upper pole layer, or the pole portion comprises an upper pole layer continued

from the upper core layer, and a gap layer located between the upper pole layer and the lower core layer; and

the upper pole layer and/or the lower pole layer comprises a soft magnetic film deposited by a production method according to Claim 24.

34. A method of manufacturing a thin film magnetic head according to Claim 31, wherein at least the portion of the core layer, which is adjacent to the magnetic gap, comprises at least two magnetic layers, or the pole layer comprises at least two layers, and the magnetic layer of the at least two magnetic layers, which contacts the magnetic gap, comprises a soft magnetic film formed by plating.

35. A method of manufacturing a thin film magnetic head according to Claim 33, wherein at least the portion of the core layer, which is adjacent to the magnetic gap, comprises at least two magnetic layers, or the pole layer comprises at least two layers, and the magnetic layer of the at least two magnetic layers, which contacts the magnetic gap, comprises a soft magnetic film formed by plating.